RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #13

Analysis of Poisson Models for ATCRBS Fruit

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SUMMARY

Discussion at Meeting #12 brought out a difference between the timing behavior of a Poisson process, which has been used for Extended Squitter performance analysis, and the actual timing behavior. Simulation results were presented showing some significant differences. It was decided to investigate this further by analyzing airborne measurements.

Substantial progress was made. We now have corresponding results derived from airborne measurements in Los Angeles and Frankfurt, which are presented in this paper. The results have been found to be different from the picture presented at the previous meeting, but the non-Poisson behavior still is important.

This paper addresses Action Item #12-07.

Analysis of Poisson Models for ATCRBS Fruit

A discussion topic at Meeting #12 focused on the timing behavior of ATCRBS fruit receptions, and how this behavior may differ from a Poisson process. Given that some of the tools used for system performance evaluation make use of a Poisson model for ATCRBS fruit, it may be important to understand the degree of this difference. At the meeting it was decided to use airborne measurements made in Los Angeles and Frankfurt to make a comparison with Poisson behavior.

Los Angeles Data

At Lincoln Laboratory, we processed data that was recorded airborne in the LA Basin in 1999. Specifically we processed the 16 seconds of data that was identified as the time of maximum ATCRBS fruit, which was recorded on 19 June 1999 at 19:45:56 GMT. We processed the data as follows. We divided the 16-second recording into 100 microsecond parts. In each part, we determined the number of ATCRBS overlaps, for which the start time occurred during the 100 microsecond period. The results are given in Table 1.

Table 1. Overlap statistics, ATCRBS > -84 dBm at antenna

Number of Overlaps	Number of Occurrences
0	37851
1	44899
2	32720
3	18742
4	10226
5	5717
6	3430
7	2178
8	1383
9	955
10	583
11	428
12	305
13	202
14	139
15	78
16	51
17	28
18	19
19	14
20	2
21	3
22	5

This distribution is plotted in Figure 1. The mean value is 1.96 overlaps. This implies that the average fruit rate is

ATCRBS fruit rate = 1.96 / 0.000100 = 19,600 / sec.

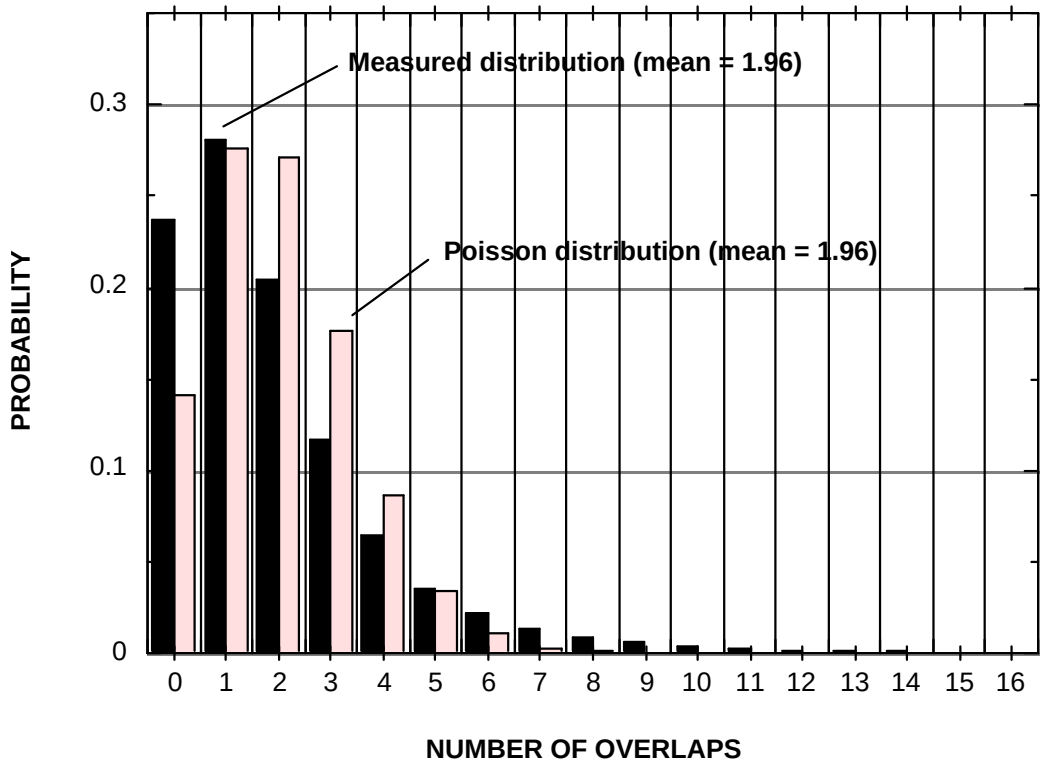

Figure 1. Number of overlaps, measured in the LA Basin.

For comparison, we calculated the Poisson distribution having the same mean (1.96). This is shown in Figure 1 along with the measurements.

The comparison shows that the two distributions are similar. Both are bell shaped. Some differences are evident, especially in the tails. The measured distribution has higher tails on both the right and left. The probability of zero overlaps and the probability of one overlap are particularly important in performance evaluation. For these two values, the Poisson distribution has lower probability, which would yield poorer performance.

Following a suggestion by Ron Staab, we have calculated the variances for these two distributions.

For the measured distribution,	mean = 1.96	variance = 4.4
For the Poisson distribution,	mean = 1.96	variance = 1.96

Note that for any Poisson distribution, the variance equals the mean. For the LA measurements, however, the variance is considerably larger. It is slightly more than twice the mean.

Correction

In discussing this subject with Alan Cameron, who was the author of the report I cited in our previous WG-3 meeting, I realized that I had incorrectly labeled his data. I had marked it as being airborne reception using an omni-directional antenna. In fact, it was ground based reception using a sector-beam antenna. Al believes that the sector-beam configuration has a more pronounced non-Poisson behavior. For our purposes, we are mainly interested in the case of airborne omni-directional reception. This difference accounts for the fact that the results presented in this paper are different from the paper I presented at the previous meeting.

Other Data

Some other data in this form was generated by APL from the Volpe simulation, run for a very high density environment. The mean and variance of this data are

For Volpe simulation:
Mean number of overlaps = 3.8 overlaps
Variance = 10.0

Although the ATCRBS fruit rate is much higher, the results are quite similar in regard to the Poisson comparison. The variance is slightly more than twice the mean.

We also ran the LA data for different receiver thresholds, therefore including more fruit in one case and less fruit in another case. The results can be summarized as follows.

LA data, lower threshold, fruit rate = 28,000/sec
Mean number of overlaps = 2.8
Variance = 6.6

LA data, higher threshold, fruit rate = 16,000/sec.
Mean number of overlaps = 1.6
Variance = 3.3

Another result was gotten by Tech Center processing of data recorded the Frankfurt and on the East Coast of the US. The East Coast results can be summarized as follows.

East Coast airborne measurements,
Mean number of overlaps = 2.57
Variance = 4.52

Figure 2 summarizes these different values of mean and variance.

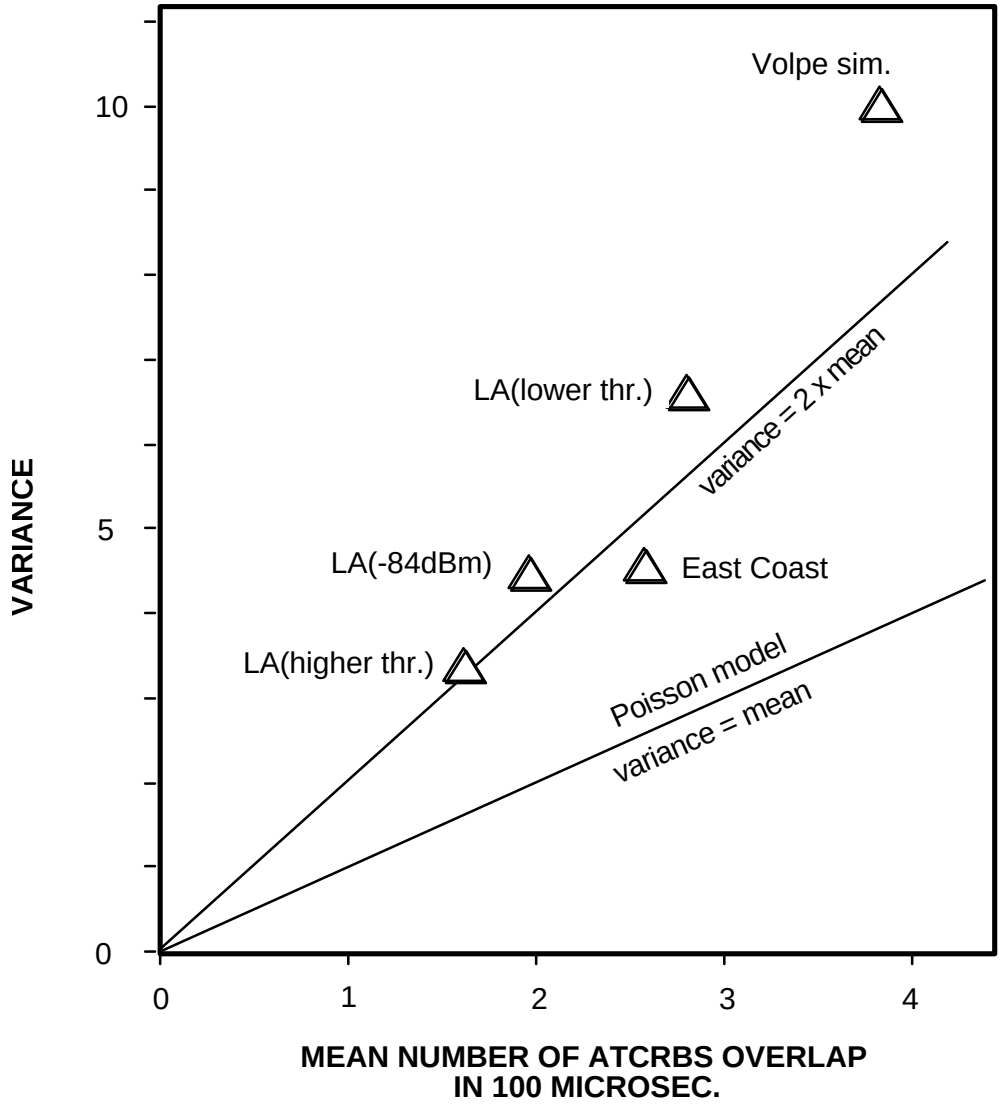

Figure 2. Means and variances in several cases.

Summary

In summary, both the measured data and the data from the very detailed Volpe simulation exhibit behavior that is similar to a Poisson process but with significant differences. Although the distribution is bell shaped, like a Poisson distribution, the tails are significantly higher than Poisson. In a number of cases for which we now have data, we see that the variance is about twice the value of the mean, and in most cases larger than that, whereas for a Poisson process the variance is always equal to the mean value.